

CHEMISTRY

JAN 22 1947

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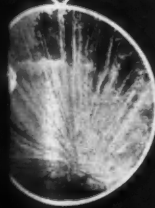
Opportunity Ahead!

Inside Front Cover

25¢



DECEMBER
1946



Opportunity Ahead!

► THE NEW YEAR finds new vistas opening in many directions for exciting progress in chemical research. Two new elements, Americium and Curium, were announced in 1946. They are not only interesting in themselves but are further proof that the nuclear reactions which created Neptunium and Plutonium are capable of extending the list of elements indefinitely.

Isotopes of varying degrees of stability not only are known for practically all the elements, but general methods for their creation are becoming better understood. Choice of chemical properties and radioactive life is thus open to researchers, who are beginning to exploit the immense possibilities of transmutation.

Replacing stable forms of such everyday elements as carbon and phosphorus by their radioisotopes, chemists can trace the utilization of these elements in life processes. Understanding can replace guess-work as to how cells assimilate and store food for our bodies' growth, how the growth mechanism goes awry to cause cancer.

Any of these fields offers almost unlimited opportunity to the young chemist who is looking for his life's work, but there is much more ahead.

Endless possibilities of exploring new compounds of such seemingly commonplace elements as silicon and fluorine have come about because new techniques have been perfected for handling materials with unusual properties.

Each of these elements holds promise of furnishing the curious researcher with a quantity of new compounds which will practically double the number of organic compounds derived from carbon. The new compounds already made from these materials are found to offer a fascinating array of novel and useful qualities, and we have only begun to work with them. There are good times ahead for those who want to learn!

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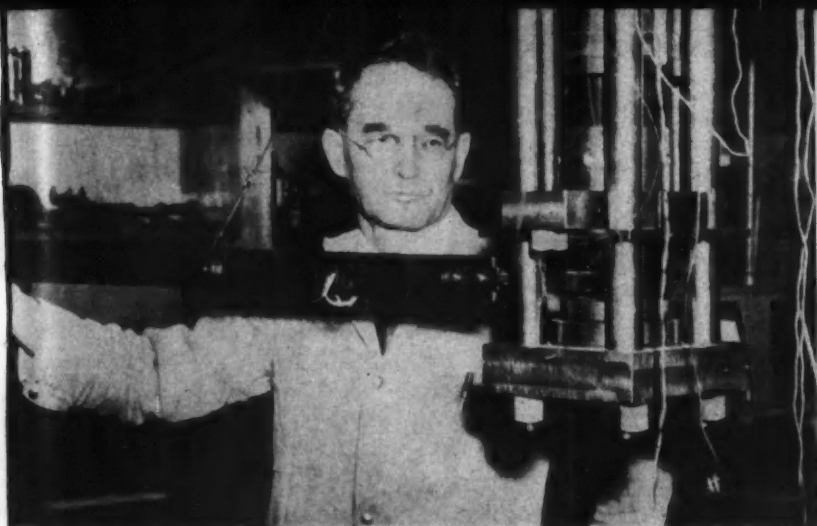
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► **DR. P. W. BRIDGMAN** *who studies matter under pressure and at the same time applies torque in the apparatus with which he is pictured here.*

FIVE AMERICAN NOBELISTS

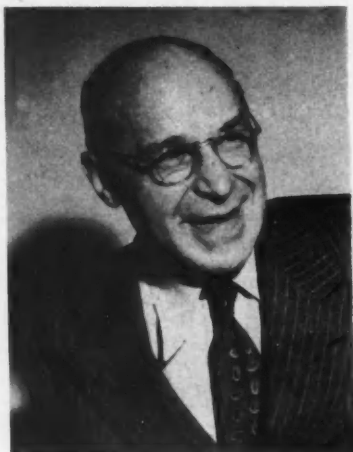
► **NOBEL PRIZES** in science all go this year to American scientists. The chemistry prize is divided, half going to Dr. James B. Sumner of Cornell University and the other half shared by Drs. Wendell M. Stanley and John H. Northrop of the Rockefeller Institute for Medical Research at Princeton. All three men have worked in fields along the border-line of life, defining in chemical terms processes formerly believed due to mysterious forces residing only in living matter.

Equally interesting to chemists is the work of the other new Nobelists, Dr. Hermann J. Muller of Indiana University, who received the prize in medical research for study of X-rays

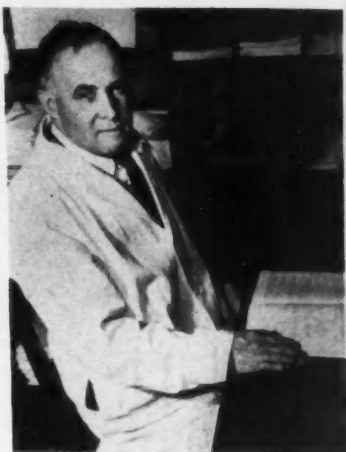
and radium rays as they affect the structure of the gene, the unit of heredity; and Dr. Percy W. Bridgman, of Harvard, who received the prize in physics for researches into the properties of matter under extreme pressure conditions.

P. W. Bridgman

► **TWO KINDS** of hot ice and several distinct varieties of the cold kind are among the spectacular results of Dr. Bridgman's high pressure experiments. Ordinary ice becomes unstable at pressures greater than 29,000 lb. sq. in. and is replaced by other forms. Dr. Bridgman began to study phenomena of this sort some twenty years



➤ **DR. H. J. MULLER** *who X-rays fruit flies to learn the effect on their genes.*



➤ **DR. J. B. SUMNER** *who was the first to prepare a crystallized enzyme.*

ago. Among the unusual kinds of ice he studied at that time was one stable at temperatures as high as 180 degrees, at a pressure of 290,000 lbs.

Later, with apparatus which gave pressures up to a million pounds per square inch, he found a new kind of hot ice, into which the older kind changes at about 25,000 atmospheres. The new ice is hotter when it melts than water boiling under ordinary conditions, and it may be made to melt at much higher temperatures by increasing the pressure.

Many materials besides water have been investigated by Dr. Bridgman with interesting consequences. He has found at increased pressures another form of phosphorus other than the red and the white allotropic forms familiar to chemists. The new form is black and a conductor of electricity.

By applying torque in addition to pressure, in the apparatus shown in the picture, such materials as rubber, cloth and paper were changed into translucent, horn-like plastics, lead dioxide detonated violently, leaving a residue of metallic lead, and graphite became hard enough to scratch steel.

Such changes in physical properties led the experimenter to wonder whether the amorphous form of carbon would shift to that of the diamond in his apparatus, but this hope was not realized. Carbon which had embedded itself in the steel face of the piston exerting the pressure changed back into soft, slippery graphite when the pressure was removed.

Problems of the behavior of rocks and minerals under the order of pressures found deep below the earth's crust have been studied by Dr.



► **DR. W. M. STANLEY** *who has learned about non-living disease causes from the tobacco mosaic virus.*



► **DR. J. H. NORTHROP** *who is searching for proteinogen, mother-substance of proteins.*

Bridgman's laboratory in cooperation with the Geological Society of America. The evidence seems to show that the deep layers of rock are less fluid than some theories had postulated. Limestone could be made to flow in laboratory pressure experiments, but it was found that rocks will break if deformation is carried far enough. Quartz did not become plastic. In general the behavior of rocks under these conditions is similar to that of metals.

H. J. Muller

► **CORRELATION** of the size of the gene, the ultimate unit of inherited life, with the size of molecules and the wave length of X-rays is within the

province of biology investigated by Dr. Muller. Working with *Drosophila*, the classic fruit fly of the geneticists, he has followed the effect of X-ray bombardment on its chromosomes, especially when a minute segment of the genetic material becomes displaced, which results in new characteristics in the individual that can be assigned to only a few genes.

Comparison of the known modifications of structure due to X-rays with results of exposure to heat, radium rays and cosmic rays is also included in Dr. Muller's work.

J. B. Sumner

► **AS THE FIRST** to crystallize an enzyme, Dr. Sumner, who prepared

crystalline urease in 1926, ranks with Wöhler who, a century earlier, broke through the division between the inorganic world and the organic by synthesizing urea.

Enzymes were thought of as more like living organisms than like inorganic chemicals until Dr. Sumner showed they could be made to take on crystalline form, a property characteristic of non-living matter.

In 1937 he crystallized catalase, another enzyme whose chief accomplishment is splitting hydrogen peroxide into oxygen and water. The function of catalase in body cells was not at that time understood, but it is believed now to regulate oxygen utilization in the tissues.

M. W. Stanley

► THE VIRUS of tobacco mosaic has been studied for many years by Dr. Stanley, who finds that growth and even evolutionary changes take place in large molecules, and that artificial production of life may come from better understanding of the structure of viruses. The cause of disease, he finds, may often reside in non-living crystals and hope for protection against virus diseases comes from success in making inactive the protein that causes them.

Ultra-swift centrifuges are used in Dr. Stanley's researches to isolate the large molecules he is investigating. Speeds attained subject the material under investigation to forces up to a quarter-million times that of gravity.

Largely because of fuel shortages several European countries are developing their natural gas deposits; these include Germany, Austria, Hungary and Italy, and to a lesser extent, France, the Low Countries and Switzerland.

J. H. Northrop

► CRYSTALLIZATION of enzymes by Dr. Northrop has broken down still further the wall between the processes that are merely chemical and those dependent upon the mysterious principle of life.

Recently he has postulated a new theory of the formation of proteins.

The manufacture in the cells of a substance, christened *proteinogen* by Dr. Northrop, would allow the subsequent making in the blood of the various kinds of proteins, which are basic materials of life.

The new theory may lead sooner to artificial antibodies for disease fighting. These could be manufactured, instead of made in a living animal or man.

Getting energy into the building process that produces the protein is provided simply by the new idea. This has been one of the stumbling blocks in working out how the body builds such materials.

The energy is put into the proteinogen molecule when it is synthesized from simpler chemicals, called amino acids. Then the normal proteins, viruses and antibodies are formed from the proteinogen mother substance without use of any new energy.

A substance made of giant molecules has been found in the blood of young cattle and unborn chickens and this may be proteinogen.

**The Bizarre Manners of
An Odd Chemical Family**

Silicones: Food For Imagination

by R. R. MCGREGOR

In presenting this delightful summary of the unusual features of silicone chemistry before the joint meeting of the Franklin Institute and the Philadelphia Science Teachers Association, Dr. McGregor stressed the value of presenting to students the new and the unusual. "When curiosity is aroused and imagination stirred," he believes, "there comes a demand rather than a mere desire for information and understanding, and the development of the student is limited then only by his mental capacity."

► THE FIELD of chemistry is generally considered as divisible into two sections: organic, or the chemistry of carbon compounds; and inorganic, which covers the chemistry of all the rest of the elements. When thought about in this way it appears that carbon considers itself rather exclusive and a law to itself.

Carbon chemistry not only appears to be exclusive, but in some ways seems to think of itself as the aristocrat of the elements. It has been systematized, organized and advertized. The chemistry of silicon has not had the notoriety of carbon, and this element may be considered a modest and unassuming member of the proletariat. It is a product of the soil, found in sand, bricks and mortar—a very humble member of society. In human relations intermarriage between different

ethnologic groups is generally frowned upon, for you never know what will come of it. This may be the reason that the families of carbon and silicon were kept apart for so long. But the union finally took place, and as a result we find a very unusual and happy progeny. At times some of them act like one of the parents, and at times like the other. On still other occasions they take on characteristics of their own. There is a complete analogy here to human behavior. Many of the children show no special aptitudes, some are brilliant in special lines, and we have at least one playboy. I would like to tell you something about this family, pointing with pride to the more promising and raising an eyebrow at the eccentric. I would like to invite you to use your imagination in a number of directions. Those of you who care to consider the pertinent chemistry may inquire into the basic reasons for some of the peculiar characteristics and actions of these offspring (for the Emily Posts of the carbon and silicon families would be shocked at some of the actions of their children); those of you who care to consider the physical differences may inquire into the reasons for unorthodox physical properties; those of you who are more interested in effects than causes may care to let your imagination take wings and, accepting the fact that many of the members of this family refuse to follow the rules that gov-

erned their parents, think of what can be done to make them useful members of society.

Chemical Genealogists

To continue the analogy we may speak of those who have studied these compounds as chemical genealogists. For a long time they spent their energies trying to show that these children really resembled their parents. And, of course, when we have our family tree investigated we always like to have it demonstrated that we are direct descendants of an emperor or a duke or some type of aristocracy. Hence for years these chemical genealogists tried to show that these organo-silicon compounds resembled aristocratic carbon more closely than plebeian silicon. Foremost among these investigators was Professor F. S. Kipping of the University of Nottingham in England. He wanted to demonstrate that silicon could be optically active, just as carbon can be. He succeeded, but it was a struggle. Over a period of 40 years, from 1900 to 1940, he investigated this family—and he found it exasperating. Some of the members acted like the carbon family, some acted like the silicon family, some acted like no known family at all—and we can imagine that he was tempted to throw them in the sink in disgust. However, he published his results—51 papers in all—thus introducing them to the world and letting those who would cultivate them or ignore them.

A Non-Conforming Family

Within the past ten years or so their acquaintance has been cultivated by several groups of chemists. But at the beginning of what we may call this

new social life they entered, they were still expected to behave like their parents. It was thought, as they showed such a high order of resistance to oxidation and could be induced to assume sticky resinous forms, that perhaps they could be transformed into a very special type of resin—a more resinous resin—an extrapolation to the *n*th degree of the properties of resins as we knew them. Or into a more carbonaceous carbon—or a more siliceous silica—perhaps actuated by the same general philosophy which Rupert Brooke's fish enunciated as he pondered the problem of a future life; for he too was not able to picture anything in the future which he had not experienced to some degree already:

Fish say, they have their Stream and Pond;

But is there anything beyond?

This life cannot be All, they swear,
For how unpleasant, if it were!

One may not doubt that, somehow,
Good

Shall come of Water and of Mud;
And, sure, the reverent eye must see
A purpose in Liquidity.

We darkly know, by Faith we cry

The future is not Wholly Dry . . .

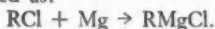
But somewhere, beyond Space and
Time

Is wetter water, slimier slime.

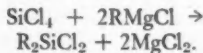
But events showed that we had come upon a group that refused to be governed by the old mores—that conformed when it chose, and deviated when it chose—a conservative or a left-winger.

Organo-Silicon Synthesis

Perhaps as good a way as any to introduce you to this family would be to show how these compounds are produced. Many of you are familiar with the processes and I will ask your indulgence while I try to give a brief explanation so that we will all be on the same ground. I realize that everyone here is not a chemist, but I believe that the method of synthesis can be described very simply. There are a number of methods that can be used, but the classical and also one commercial method of preparing them is by the use of the method developed by Grignard and known as the Grignard reaction. In this method magnesium chips are covered with dry ether. An organic halide such as phenyl chloride is dripped into this while it is stirred. The temperature rises, the ether refluxes, and in time the magnesium disappears. Under the best conditions a clear solution results. The reaction is described as:

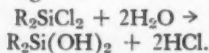


If then this solution is dripped into silicon tetrachloride in ether solution, magnesium chloride separates out as a result of the reaction:



The R_2SiCl_2 may be distilled off and is the raw material for preparation of a silicone.

If this is treated with water there is an immediate hydrolysis of the chlorides giving:



If that were all there was to it Kipping would have had a good time, for

he could have isolated $\text{R}_2\text{Si}(\text{OH})_2$ or any other similar product he cared to make, determined the properties, and showed its position in the family tree.

But these compounds are not so obliging. The $(\text{OH})_2$ groups are unstable and split out water, leaving an oxygen. Even this wouldn't be too bad for then we would have R_2SiO or a ketone type. It seems to be a strange thing, but silicon never is combined with oxygen by a double bond except perhaps in the vapor state. So what we really have is O-SiR-O-SiR , which is a polymer. This was Kipping's greatest worry and the industrialist's greatest hope.

It is the control of this polymerization that spells success or disaster for the industrialist; for these various polymers carried to just the proper polymer size are the articles of commerce.

Properties of Fluid Polymers

And now to look at some of the progeny of these fruitful parents.

We may consider first the group of fluid polymers. Here we have a liquid that looks like highly refined petroleum oil. We should expect it to resemble the carbon parent; but if it is analyzed it will show about 80 per cent silica. If it contains that much silica it should at least solidify by being chilled; but it doesn't freeze until it reaches 40 degrees below zero; and here is another that doesn't freeze until it reaches 100 degrees below zero F. Why is this? Both the carbon compounds and the silicon compounds generally freeze far above these temperatures. We are beginning to get hazy ideas as to the reasons back of this, but someone with insight and

with imagination must yet supply the complete answer.

Not only do these liquids have low freezing points, but they show less change of viscosity with temperature than any other liquid.

They resist oxidation and have had pure oxygen bubbled through them while they were held at 200° C. After hours of this drastic treatment the change in properties was scarcely measurable.

When I add to these statements that the electrical properties are unusually good, you may have some food for imagination as to what is the cause of all this and what you can do with such materials.

Organo-Silicon Greases

It is possible to compound these fluids into greases. Many of the properties inherent in the fluids are still present, such as water repellency, oxidation resistance, etc.; but some of them are enhanced—for instance, the change of viscosity with temperature. Within some kind of reasonable limits—40 below to 400 above—there is no change in viscosity at all. They don't run with heat, although it is possible, at quite elevated temperature, to make them burn. Their lack of flow coupled with good electrical properties makes them good dielectrics for hot locations. They stay put! They are useful as lubricants in places where heat would smoke off ordinary petroleum lubricants. Why don't they flow with heat? There may be food for imagination here in supplying the answer, and similarly there may be food for imagination in thinking what can be done with such materials.

Heat Resistant Resins

The greases show no flow with temperature, but they are soft.

Here is another type of polymer that shows no flow with temperature, but it is solid. This is a piece of Fiberglass cloth impregnated with a silicone resin. It is flexible, heat resistant, water repellent, and an excellent electrical insulator. It surprises a great many people to learn that the only function of an electrical insulator is to keep out water. Well, then, what's the matter with rubber? Not a thing, as long as it stays rubber. But a motor or any piece of electrical apparatus that is worked hard or is subject to overload becomes hot. If it becomes very hot the rubber softens, oxidizes, decomposes, lets water in, there is a "short," and the motor burns out. The advantage of the silicone insulation is that it does not decompose except at quite high temperature; therefore it continues to keep water out even though the equipment is heavily overloaded. Motor tests are in progress right now where the temperature is held above 300° C. It is frequently shut down and held at 100% humidity until the motor is dripping wet. The paint has been burned off the frame; but the motors are still functioning smoothly for the insulation is remaining intact and is keeping out the water.

Similar resins can be used to bond layers of glass fabric together to provide panel boards for electrical instruments. If an arc is formed as a result of high voltage no carbon track is formed, but rather a silica track which gives even better insulation.

May I raise another question right

here for your imagination to work on? When the general run of carbon containing compounds are raised to 250° or 300° C., they oxidize fairly readily and CO₂ is formed. But if the carbon is attached to silicon it is much more difficult to bring about oxidation. If one carbon atom (methyl) is attached, oxidation is very difficult; but if two carbons in a chain (ethyl) are attached, oxidation is easier. As this chain is lengthened, oxidation progresses more and more readily. Why does silicon exert such a protective action within its sphere of influence?

This oxidation protective action is shown where the resins are formulated into paints. Such paints remain coherent and protective long after the best of the organic paints have flaked off and disappeared. One nice place to use the new paint in the home is on the hot water heater. After a test of a year in one case with which I am acquainted the heater looks as bright and shiny as the day it was applied. Why they are so heat resistant and what should be done with them I leave to your imagination.

The Skeleton in the Closet

But every family has some sort of a skeleton in the closet—perhaps a grandfather who was addicted to strong drink, or an uncle who ran off with an actress—or a cousin who voted the Democratic ticket. There's a certain lurid fascination about them, but they really reflect very little credit, and they are rarely spoken of outside the family circle.

But it seems only fair tonight, since we are looking at the carbon-silicon

family with an appraising glance, that we should take note of at least one of the skeletons in the closet. I refer to the silicone man-about-town, commonly referred to as Bouncing Putty. He seems quite irresponsible, breaks the laws and does no useful work. He is tolerated because he is an eccentric. As with most of such folks he is recognized as a member of the family only on social occasions. Some day he may settle down and be of some use to the community, but so far he seems scarcely worth the trouble it took to raise him.

This Bouncing Putty can really be looked at in a more serious vein. I said before that he breaks all the laws—and that is just about what I meant. It doesn't correspond with our experience to find a material that can be drawn out into long threads and has cold flow, that can at the same time be readily fractured or broken. And then to find that this material has a high rebound when dropped—well, it just doesn't add up. It is an interesting fact that children see nothing unusual about it. It's fun, because they can do different things with it. But they find nothing paradoxical about it. To those who have had some experience in the testing and correlation of physical properties it presents some interesting problems. Your imagination might be stirred by consideration of such a material as this. Some of you may inquire what are the reasons behind these peculiarities; others, accepting the fact that these properties are present, may want to ask what you can do with them. In spite of this peculiar combination of properties *we* don't know what to do with it.

Rubber With 90 Per Cent Ash

There is one more member of this family I would like to introduce to you. It is known as Silicone Rubber or Silastic. You will note that it looks like a white rubber. It stretches, it bounces, it makes a good **waterproof**. It must be rubber! But if you burn this down to an ash you will find that you have left not the 5 per cent to 10 per cent usually left by rubber, but about 90 per cent. In other words, it is nearly all inorganic. What manner of thing is this that has so many of the physical properties of an organic material and yet declares itself on analysis to be nearly all inorganic?

It is thought of as a rubber because it stretches and bounces, but there the analogy ceases. It does not soften on heating as rubber does; it does not freeze as readily upon drastic cooling; it is not affected by petroleum oils. It is very resistant to oxidation and ozone. Chemically it does not even remotely resemble rubber, for it has no double bonds and is not vulcanized by sulfur. Rubber has been studied carefully over many years and so far there is no theory about its structure that is universally accepted. The Silicone Rubber, or Silastic, is not any more willing to yield its secret. There is plenty of room for imagination here.

Another Frontier of Knowledge

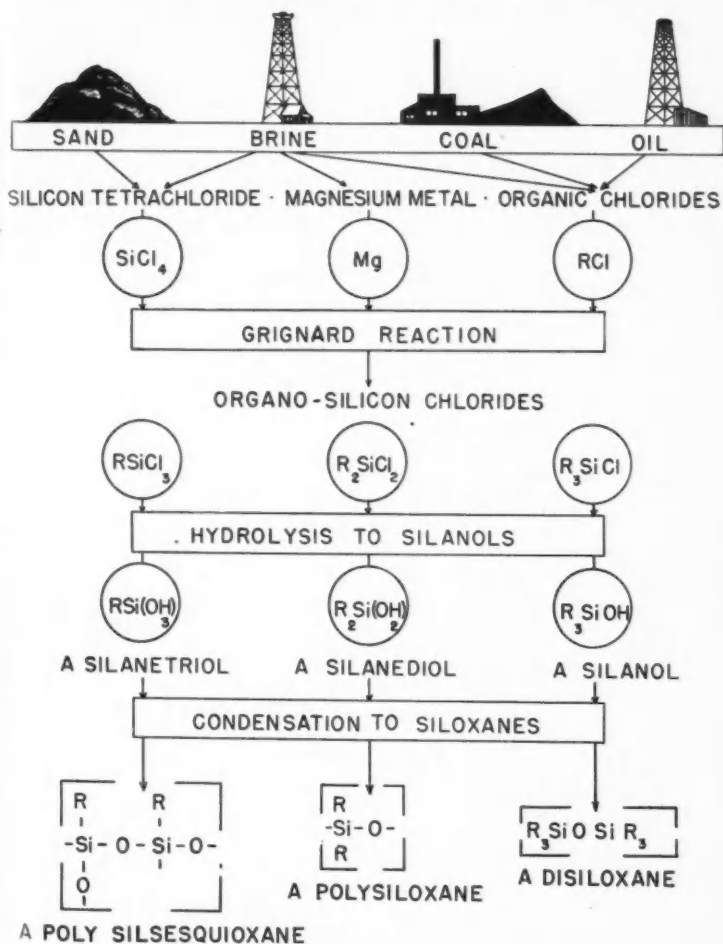
The materials described and shown comprise the main types of compounds so far prepared. If time permitted the list could be extended.

It has not been my purpose tonight to tell you all about these materials, but rather to present them in such a way that you may see the peculiar position they occupy as chemical compounds and as engineering materials. To tell you the truth, we're a bit puzzled ourselves about what some of them are, why they behave as they do, and what to do with them. I may as well admit that it's fun to work with them. They provide plenty of room for chemical investigation and for engineering imagination, for you can take nothing for granted.

Addressing myself more particularly to teachers of science, I could suggest that the description of such materials to the student might help him to realize that the last frontiers of knowledge and invention have not been passed—that more and more lies beyond the horizon. Other problems and products not thought of now can without doubt be found, and the excitement of search and discovery awaits those with energy and active imagination.

➤ IN THE DIAGRAM on the opposite page Dr. McGregor has outlined the methods used in the preparation of silicone compounds and given a key to the nomenclature of this new branch of chemistry. ➤

THE FORMATION OF SILICONES



SIMPLE TYPES OF STRUCTURAL UNITS PRESENT IN SILICONES

How Silicone Polymers Are Built from Chains

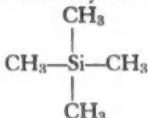
Siloxane Linkage

by E. G. ROCHOW

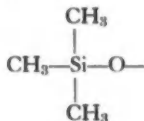
Research Laboratory, General Electric Co., Schenectady, N. Y.

In this excerpt from his paper presented before the Electro-chemical Society, Inc., October 18, 1946 at Toronto, Ontario, the author describes the fundamental types of structure characteristic of silicone polymers. They are based, he states, upon "chains, rings, and networks of alternate silicon and oxygen atoms. This immediately distinguishes the silicones from the organic plastics and from natural and synthetic rubber and the petroleum oils, all of which are based upon networks of carbon atoms.

➤ WE NOW TURN to the actual structural units which make up the different silicone polymers. It is convenient to describe the units in terms of their functionality, to borrow a concept from the theory of organic polymers, and we shall have five general cases to consider. The first is represented by tetramethyl silane,

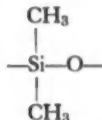


which is not a siloxane and has no reactive positions. Its functionality is zero; it could take no part in building a polymer. With one less methyl group and one valence of silicon satisfied by oxygen, we have the trimethylsiloxy group,



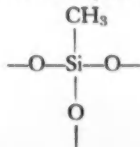
which is monofunctional; it is capable of ending a chain but not of propagating one. It acts as a chain-blocking unit or terminal group, and serves to prevent further growth of the chain.

With only two methyl groups per silicon atom we have the dimethylsiloxy group,



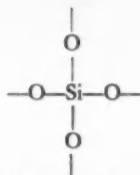
which is difunctional. This is the important chain-builder in the methylpolysiloxanes; it extends linear or cyclic polymers but does no chain-ending or cross-linking. Polymers composed solely of dimethylsiloxane units would necessarily be cyclic or of infinite chain length.

If three atoms of oxygen and one methyl group are linked to silicon, we have the monomethylsiloxane unit:



This is trifunctional; it can not only extend a chain or enlarge a ring, but also can establish an oxygen bridge or cross link to another silicon atom. If it joins with a similar group in a neighboring chain or ring, the two aggregates thereby are combined into one molecule and the molecular weight is increased. If it joins with a bifunctional unit instead, a branched chain is set up. If it joins with a monofunctional unit, the branch ends right there.

The last unit to consider is that which occurs in silicon dioxide.



This unit is seen to be tetrafunctional and hence capable of extending two chains or creating two branches. While it has no organic groups, it may become a part of an organosiloxane. It probably has much the same configuration whether it occurs in a quartz crystal or in a cross-linked silicone resin.

Lignin in Soil Fertilization

► LIGNIN, next to cellulose the chief material in cell walls of trees and woody plants, has a definite value in soil fertilization, recent experiments indicate. A report on the uses of this plentiful material obtained from wood waste was given to the American Society of Mechanical Engineers by Stuart Dunn and Joseph Seiberlich of the University of New Hampshire.

The addition of lignin to soils may be beneficial in many ways, these university scientists asserted. It improves soil texture, affords better water-penetration and water-holding capacity, and possibly gives stimulus to higher plants from minute quantities of organic substances resulting from the action of micro-organisms.

The chemical nature of lignin is not yet clear. Very little is known about the chemical and physical structure of this compound and products formed by its decomposition, due largely to

the difficulty of isolating lignin from plant material in its chemically unchanged form. Therefore, these researchers said, a distinction should be made between two types of lignin.

The first type of lignin is as it occurs in the living plant or tree. This is called "protolignin" or unaltered lignin. The second type includes lignin derived from plants and trees by chemical or biological action from the combined material known as lignocellulose, whose chief constituents are lignin and cellulose.

Plant lignin during its separation process condenses to larger units by polymerization. The isolated lignin enters the field of high molecular substances of colloidal type. These colloidal properties seem of special interest where lignins are used as carriers or adsorbents for substances to be applied as a fertilizer.

Twenty New Vitamins

► WATCH FOR new treatments of disease and better understanding of human ills to come from inquiries into about 20 mysterious vitamins and growth factors.

The Princeton bicentennial conference on growth received from Dr. Karl Folkers, Merck research director, a list of unidentified food factors that are additional to the ones that you read about or take in pills.

Latest of these include an anti-stiffness factor that shows up in guinea pigs, an unnamed feeding factor

needed by chicks, and unrecognized vitamins that pigs must have.

One of the most recently discovered vitamins that has been put to use is folic acid. It formerly was thought to be something that only bugs needed. Then it was discovered that it plays an important role in warding off many kinds of anemia.

Scientists now expect that other little understood food factors will turn out to be necessary for well-being or useful in treating disease.

American Cork Oaks Flourish

► AMERICAN-GROWN CORK moved one step closer to becoming a full-fledged industry, with the stripping of more than 1,000 pounds of second-growth cork from trees in California, six years after the first, or virgin bark had been removed. This second-growth, or reproduction bark ranged between one and one and one-half inches in thickness and was of first-grade commercial quality.

The movement for the large-scale planting of cork-oaks in the United States, to supply at least a part of the nation's cork requirement, was established by the late Charles E. McManus, former president and chairman of the board of the Crown Cork and Seal Company. Initiated more than six years ago in California, the cork project is active in 22 states today.

During the past six years more than 12 tons of virgin cork have been removed from over 500 cork trees. All of this cork has been processed and manufactured into cork products for thorough testing. In every case the home-grown product was found equal to the imported material of the same grade.

In the same period some 18 tons of cork-oak acorns have been collected and distributed over the warmer half of the country. This outstanding progress in planting cork-oaks has been achieved through the effective cooperation of forestry specialists and agricultural advisers interested in tree culture. Thousands of little cork-oaks are now growing from coast to coast and thousands more are being planted each year.

Chem Quiz

Chemistry in Mother Goose

► IN HOLIDAY SPIRIT we revisited Mother Goose, and found that several of her friends are pretty good chemists. Can you identify these well-known characters? If not, you may hippety-hop to page 44 for the answers, if not a stick of candy.

1. Which Jack knew about proteins?
2. Which Jack knew about carbohydrates?
3. Which Jack knew about H_2O and acetic acid?
4. Which Jack knew about combustion?
5. What little girl knew about casein and lactic acid?
6. What calamity involved albumin and calcium carbonate?
7. Who captained the ship that was rigged with a precious metal and animal fiber?
8. Who grew a precious metal in her garden?
9. Who used another metal for ammunition?
10. What queen used a liquid balsam for cosmetic purposes?

Better Aluminum Mirrors

► BETTER MIRRORS, with aluminum reflecting surfaces, are made by a simple evaporation method explained to the Optical Society of America by Noel W. Scott of the Radiation Engineering Branch of the Army Engineering Board, Fort Belvoir, Va. The process is used to produce front surface mirrors with good abrasion, corrosion and reflection qualities.

Aluminum is used as the reflecting material because evaporated aluminum films have a high reflectivity in all useful spectral ranges. Also, they show a much finer grain and smoother surface than similar silver coatings when viewed under the electron microscope, he added. The method will have its principal application in mak-

ing mirrors for scientific instruments.

The fine grained smooth surface is important, he said, for the deposition of effective protective coatings on the mirror and for minimizing diffuse reflection. As protection for the mirror surfaces silicon oxide layers are used. He described successful means of depositing the silicon oxide by an evaporation process.

Direct evaporation of silicon dioxide produces loose layers. He uses a mixture of silicon metal and silicon dioxide. This gives a silicon monoxide deposit on the mirror in uniform and adherent layers which, when exposed to the air, partially oxidizes to silicon dioxide.

Vitamin B Complex from Yeast

► A FUNGUS that causes one of the most destructive of plant diseases, flax wilt, has been found to be a potential source of most of the B vitamins, in researches by a four-man team in the laboratories of Fordham University.

The fungus, known to botanists as *Fusarium lini*, was grown in quantity on a stock culture medium containing glucose. The matted growth was ground up after being dried, and

added to a vitamin-deficient diet fed to rats. It was found necessary to add thiamin (vitamin B₁), but the dried mold-like substance proved an adequate source of other vitamin B constituents, "comparing favorably with brewer's yeast."

Collaborating in the research were Leonard J. Vinson, Prof. Leopold R. Cerecedo, Robert P. Mull and F. F. Nord.

Fluorine Helps Growing Teeth

► GREATER PROTECTION against tooth decay is now possible, latest findings on the fluorine vs. caries situation show.

That small amounts of fluorine in the drinking water help prevent caries, or tooth decay, is an old story. At least two fairly large cities are now adding fluorine to their water supplies to take advantage of its anti-caries action. But this measure was not expected to help anyone except children born in those cities after the water supply was fluorinated. Fluorine, it has been believed, only protected the teeth of persons drinking fluorinated water from birth and during the period while the teeth are developing in the jaw.

Its good effects, it has just been discovered, can be applied at considerably later ages. First and second molars and second bicusps that are already erupted in the mouth can be protected by fluorinated drinking water if they are exposed to the fluor-

inated water within a short time after eruption.

This means that in cities where fluorination has been started not only the new babies and toddlers but children up to about 14 years old will have better teeth and fewer toothaches.

The new finding was announced by Dr. Henry Klein, of the U. S. Public Health Service, in the *Journal of the American Dental Association*.

It was made on children of Japanese ancestry transferred late in 1942 from their homes in Los Angeles to War Relocation Centers in California and Arizona. At the California center the drinking water contained almost no fluorine. At the Arizona center the water supply contained just about the caries-preventing amount of fluorine. Children who were between eight and 14 years at the time of relocation who went to the fluorine region had considerably less new caries in the teeth most susceptible to decay than the children who lived two years in the fluorine-free water region.

How War-Necessitated Research Solved Polymerization Mystery

How Synthetic Rubber Grows

➤ RUBBER AND many other plastics are formed by agitation of an oil in a soap solution. If the rubber is for tires the oil may be 75% butadiene and 25% styrene, small molecules which unite with each other to form extremely long chain-like rubber molecules, a few of them as long as, or even longer than, one twenty-fifth of a thousandth of an inch. This distance is also the diameter of many of the oil droplets formed in the first step of the process, the formation of an oil-in-water emulsion by agitation of the oil with a soap solution.

Before the war the theory of where and how the rubber polymer is formed was not understood. This year Professor William D. Harkins of the University of Chicago revealed, in a paper presented before the National Academy of Sciences, his new theory, actually developed in 1942-43 but kept secret during the war, of how synthetic rubber grows in soap solutions.

The Germans had two naive theories: (1) that the oil droplets change to rubber when the emulsion is heated after a minute amount of a catalyst is added; (2) that the polymer is formed in the water. Professor Harkins has proved that, while correct, these are factors of only minor importance. The correct theory is as follows:

1. Practically all of the excessively small rubber particles are initiated, or born, in excessively thin oil layers,

about one thirty-fifth of a millionth of an inch in thickness, and are then ejected from these into the water.

2. These rubber particles take up oil, which turns into rubber, finally producing a sphere of rubber which is often a third of a millionth of an inch in diameter. Almost all of the rubber produced in the United States grows in these minute spheres.

Soap solutions spread oil in extremely thin layers. This gives the oil an extremely large area: ten acres of surface per cubic inch of oil. The thinness and large area of the oil film causes the rubber particles which form from it to be so small that a cubic inch of oil would hold 200 billion of the small spheres.

To obtain such very thin oil layers requires no skill on the part of the chemist. It does not even require a chemist's services, since each of us produces these oil layers whenever we wash our hands with soap. Soap dissolved in water has itself the property of dissolving oils in such extremely thin layers.

About thirty years ago, both Dr. Harkins and Dr. A. C. Langmuir of the General Electric Co. showed that oil molecules on the surface of water stand upright like soldiers on parade on the surface of water, although they may lie flat if sufficient room is available. Hardy, a noted English scientist, also suggested the general idea, but

did not develop it. This "theory of the orientation of molecules on surfaces" has not only revolutionized certain branches of chemistry but is also having a profound influence in biology.

Soap molecules, when crowded together, stand upright on the surface of water. In addition, they form sandwich-like layers inside the water. In these sandwiches the oil takes the place of the butter, while two oriented layers of soap molecules replace the bread. The molecules of soap stand upright on both sides of the layer of oil, with their oil-like ends toward the layer of oil and their water-like ends toward layers of water on each side. Such groups of oriented molecules are known as *micelles*. A double layer of soap, with its inner layer of oil is about five millionths of an inch thick.

In these oil layers the very short single, or monomer, molecules grow into very much longer molecules. The short chain of a short molecule unites at one end with the end of another short chain, and this continues until a long chain, or polymer, molecule is built up. A thousand short monomer molecules may thus grow together to give a single long chain polymer molecule. In some plastics fifteen thousand or many more may unite. The properties of the rubber depend to a considerable extent upon the length of the molecule thus built up.

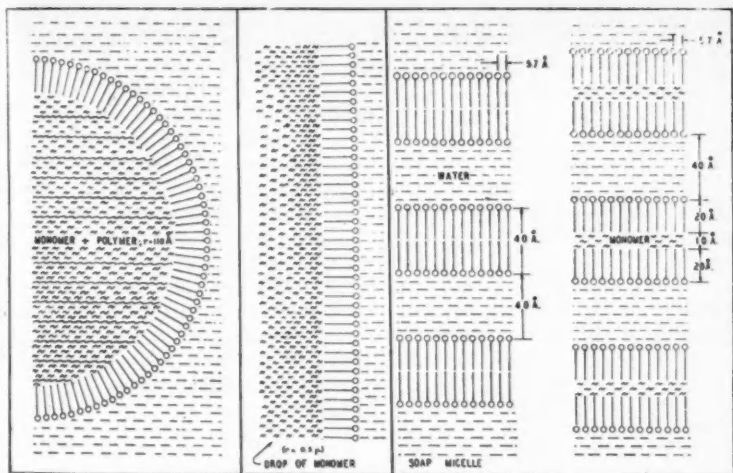
These long molecules coil up and become too thick to be held in the soap micelle and are then ejected into the surrounding water as a rubber, or polymer, particle. It is in the rubber particles formed in this way that almost all the rubber is subsequently produced. The rubber particle takes

up monomer from the emulsion droplets and this polymerizes, and so the rubber particle grows in size until all of the monomer (oil) disappears. However, when fully grown, the rubber particles are not large. Usually they have a diameter of only about three-millionths of an inch. If very little or no soap is used the particles grow to be very much larger, but only a few particles can form.

While it is possible to produce a little rubber without the use of soap, the rate of rubber production is greatly increased if soap is used. Theoretically, says Dr. Harkins, "the overall rate of polymerization should be directly proportional to the initial total amount of micellar soap present in the solution." Within limits affected by various other factors, this generalization is found to hold true, so that the use of more soap makes rubber form faster.

Every rubber particle collects and absorbs a layer of soap molecules at the interface between the sphere of rubber and the water. This robs the micelles of their soap, so they disappear when about 12 per cent of the oil has been converted into rubber. After this there remain no thin oil (monomer) layers, since the "sandwich" has been destroyed. After this, very few *new* rubber particles can be formed, although some are initiated in the water, so they remain almost constant in number and simply grow larger.

The complete theory is more complicated, but the principal relations have been given. Many other monomers are used for the production of types of rubber other than for tires, or of plastics other than rubber.



► AT THE RIGHT-HAND side of this diagram, thin layers of monomer are indicated, sandwiched between two layers of oriented molecules. The monomer in this case may be an oily layer composed of 75% butadiene and 25% styrene. The oriented molecules are soap, which, in water, arranged themselves to form layers in much the way the diagram shows, giving rise to micelle structures. When the monomer is enclosed in the soap micelle its molecules combine with one another to form the polymer, which is rubber. Enlarged diagrams showing one surface of a drop of monomer in a micelle, and the structure of half a drop of rubber in the liquid, surrounded by a soap film, appear at the left.

Washability Interests Buyers

► "WILL IT WASH?" is the first question most customers ask when looking for a piece of material, according to a survey made by the Textile Resin Department of the American Cyanamid Company. A survey of 120 leading department stores in 35 states showed that washability of all types of fabrics is rated as the most important single quality desired by customers.

Eighty per cent of the stores asked for wool fabrics that can be washed

without fear of harmful shrinking or felting. They feel that knitwear, sweaters, children's clothes, blankets and sportswear should be shrinkproof.

Control of shrinking and stretching of rayon fabrics was also widely requested, with many stores pointing out the present tendency of rayon dresses to sag while hanging on the racks. Almost 60% of the stores asked for a finish for acetate rayons that would keep blue and green fabrics from fading.

For the Home Lab

Speed Of a Chemical Reaction

by BURTON L. HAWK

➤ LET US CONSIDER, for a moment, a crystal of common salt. It is composed of sodium ions and chloride ions held together by the powerful attraction of opposite charges—positive and negative. When this crystal is dissolved in water, the ions are separated and are free to combine with other ions that may be introduced. If a solution of silver nitrate is mixed with a solution of sodium chloride, a white precipitate is formed *immediately*, thus illustrating the incredible speed of the reacting ions.

Another example of the speed of chemical reactions can be shown readily in a fascinating experiment. Sometimes known as the "iodine-clock", this experiment may be familiar to you. If so, we ask that you forgive repetition for the sake of others who have not yet performed it.

Two solutions are required. Solution A is made by dissolving 1 gram of potassium iodate in 500 ml. of water.

But, you do not have potassium iodate? Then, simply manufacture your own! Now if potassium chlorate can be made by the action of chlorine on potassium hydroxide solution, is there any reason why iodine cannot be used similarly to produce potassium iodate? No reason at all. Add 1 gram of iodine crystals to 20 or 30 ml. of warm potassium hydroxide solution. Heat if necessary to dissolve all the crystals. The reaction is: $3I_2 + 6KOH$

$\rightarrow KIO_3 + 5KI + 3H_2O$. You will note that potassium iodide (KI) is also formed. Evaporate the solution nearly to dryness; the iodate, being less soluble, will crystallize first. Or better still, heat to dryness and dissolve the entire residue in alcohol (either grain or wood alcohol). The iodide will dissolve, leaving the iodate, which can be obtained by filtering and carefully drying.

Using another line of thought, if potassium iodate is KIO_3 , is there any reason why it cannot be prepared by oxidizing potassium iodide—KI? No reason at all. Mix a solution of potassium iodide with a solution of potassium permanganate, the latter in excess, and heat to boiling for a few minutes. The reaction is: $KI + 2KMnO_4 + H_2O \rightarrow KIO_3 + 2KOH + 2MnO_2$. Filter off the brown precipitate (MnO_2) and evaporate the filtrate to dryness. Alcohol will dissolve the KOH, leaving the iodate.

Now we are ready for solution B. Dissolve 0.2 grams of sodium bisulfite in 450 ml. of water. Add to this 3 ml. of molar sulfuric acid. (In case you have forgotten, a brief explanation may be in order. A *molar* solution contains one gram-molecular weight of the solute in 1 liter of solution. The gram-molecular weight of sulfuric acid is 98 ($H_2 = 2$; $3 \times 32 = 96$)—therefore 98 grams in 1000 ml. or approximately 50 grams in 500 ml. or 1 gram in 10 ml. represents a molar

solution. The specific gravity of sulfuric acid is 1.84, meaning 1.84 or approximately 2 grams occupy 1 ml.; thus 1 gram of acid in 10 ml. would be equivalent to 1 ml. of acid in 20 ml. of solution. Therefore add 1 ml. of acid to 20 ml. of water . . . and why didn't we say this in the first place?). Also add 50 ml. of starch suspension, made by dissolving 1 gram of starch in 50 ml. of hot water. Cool thoroughly before adding.

Now mix equal quantities of the two solutions. After about 20 or 30 seconds the liquid will suddenly turn blue-black without any apparent reason or cause. This appears rather baffling to those not acquainted with chemistry, which is the reason for the popularity of the experiment as a public demonstration stunt. The demonstrator, through experience and careful preparation of solutions, knows exactly when the solution will darken in color. He places the colorless liquid in view of the audience. At the exact moment he waves a "magic" wand over the vessel and the colorless solution turns black.

How It Happens

If you are a true scientist, you will want to know why the solution behaves as it does. We shall attempt to satisfy your curiosity.

When the solutions are mixed, iodic acid, HIO_3 , and sulfurous acid, H_2SO_3 , are formed which immediately react with each other: (1) $\text{HIO}_3 + 3\text{H}_2\text{SO}_3 \rightarrow \text{HI} + 3\text{H}_2\text{SO}_4$. As fast

as the hydriodic acid (HI) is formed, it reacts with the unused iodic acid present forming free iodine: (2) $\text{HIO}_3 + 5\text{HI} \rightarrow 3\text{I}_2 + 3\text{H}_2\text{O}$. The free iodine immediately reacts with any unused sulfurous acid to form hydriodic acid again: (3) $\text{I}_2 + \text{H}_2\text{SO}_3 + \text{H}_2\text{O} \rightarrow 2\text{HI} + \text{H}_2\text{SO}_4$, and thus the cycle continues until all the sulfurous acid is used. The free iodine then remains in solution and with the starch forms the intense blue-black color. The first reaction is slower than the last. The time required for the three reactions to reach completion accounts for the lapse of time before the change of color. The speed of the reactions can be increased by concentration or by heat.

With practice and patience, you can develop this experiment into an art. By diluting or concentrating the solutions involved you can bring about the color change at any time you wish.

If sodium bisulfite is added to the blue solution it will become colorless again. The supply of sulfurous acid is thereby replenished, and the free iodine combines with it (reaction 3 above).

This experiment vividly illustrates the remarkable regularity and intricacy that exist in the infinitesimal world of ions and molecules! Who would think that in the innocent-looking solution there is a raging inferno of reactions—combining and recombining, crashing and colliding back and forth with unimaginable speed!

Industrial laboratories were maintained by 297 firms in the United States in 1920 and employed 7,400 workers; by 1940 the number of such laboratories had increased to 2,350 employing approximately 70,000 technicians.

Silver Manganese Solder

➤ SILVER MANGANESE solder that can withstand the temperature within gas jet turbines was found in Germany by American investigators. It is a material that should have wide value in the United States.

In addition to its use in turbines, the solder can be used in the fabrication of stainless steel heat exchangers, exhaust manifolds, gas turbine parts, and general chemical equipment where high heat is encountered.

The solder is made of 85% commercially pure silver and 15% mang-

anese. Addition of manganese to pure silver in this proportion gives an alloy with excellent soldering properties, it is said, and does not lower the melting point of the silver. The solder has a melting point of 1790 degrees Fahrenheit, and retains its high strength up to 850 degrees Fahrenheit.

A report of the silver-manganese solder with additional facts relative to it was issued by the Office of Technical Services, U. S. Department of Commerce.

Iron and Titanium Ore Reserves

➤ BOTH IRON and titanium may some day be obtained commercially from America's large reserves of titaniferous iron ores, the U.S. Bureau of Mines indicates.

Present methods of reducing the ore are not economical, but a cheap and satisfactory method may result from present efforts. When easily worked ores are exhausted, these reserves will become valuable.

Two methods of processing the ore have been developed and used experimentally by the Bureau. In one ores were roasted with carbon and the reduced iron was determined by leaching with sulfuric acid. In the other, ores were roasted with carbon and sodium carbonate, and the reduced iron was separated magnetically from the finely ground roasted product.

Under the first method, the bureau states, about 90% of the iron was

made acid-soluble, with only a small percent loss of titania. The leached residues contained a percentage of titania which was about 2.5 times the percentage in the original ores.

Results of the second method indicated that it is possible to obtain magnetic fractions analyzing 90% to 95% iron, and 1% to 3% titania. The non-magnetic part analyzes from 40% to 70% titania, depending upon the original titania content of the ore.

Titanium has become an important industrial metal in America during the past two decades, much of which is produced domestically from ilmenite and rutile. About 90% of the titanium is used as a pigment in paint and other coating materials, the rest principally in construction and metallurgical materials. As a constructional material, titania is very important as a welding-rod coating.

New Plants for Oxygen Production May Be Either Tiny or Tremendous

A Burning Matter

Reprinted from the Industrial Bulletin of Arthur D. Little, Inc.

► CHEAP OXYGEN is coming soon. War-time advances in the separation of oxygen from the atmosphere have appreciably reduced costs. The new methods, furthermore, make possible the design of simple plants which may be small enough for industrial consumers to operate or, alternatively, large enough for process uses on a scale never before seriously considered. One company has a gigantic plant under construction, another company offers to lease small plants to supply individual factories or oxygen dealers, still another is designing a small plant for sale, and a construction company offers to build large plants to supply oxygen for consumption in industrial processes, where the volumes used might outstrip anything heretofore considered.

Oxygen has commonly been made by compressing air to about 3000 pounds per square inch, chemically removing impurities such as carbon dioxide and water vapor, and, after it has been cooled in a heat exchanger, allowing it to expand through an orifice. The liquid air resulting from the cooling effect of this expansion is distilled to separate the oxygen from the nitrogen. The oxygen is then again compressed and run into the familiar yellow or green cylinders in which it is sold. Since the cylinders are heavy and expensive to ship, oxygen plants must now be located in

each industrial center. Shortly before the war, liquid oxygen was being sold to large users in insulated tank cars and tank trucks. This method avoided the final compression and the expensive cylinders and permitted relatively long-distance shipment from large central plants to the various industrial centers requiring oxygen.

A leading use of oxygen is in clearing up the surface of steel before rolling, to avoid imperfections in the finished article. Large quantities are also used for welding and especially for cutting, since the flame burns through the metal easily. Among the other uses for the oxyacetylene flame are the heat hardening of metals and removal of scale from steel in process. Production of oxygen in the United States in 1939 was 4.6 billion cubic feet, valued at \$24,000,000; during the war it was greatly increased to supply the metal-working industries, especially for the tremendous shipbuilding activity; now it is said to be a \$100,000,000 a year business.

The armed services needed oxygen in the field for repair work and use in high-altitude aircraft. Since cylinders were not desirable for exporting oxygen, research on the development of a small, preferably portable oxygen generator was initiated. This program led to three improvements which taken together went beyond the original objectives. One is a heat exchanger in

which the cold waste nitrogen cools the incoming air and freezes out the impurities. To avoid plugging, the channels of the exchanger are so arranged that nitrogen can be switched into the channel containing the ice and solid carbon dioxide, where it evaporates them and exhausts them to the atmosphere. Incoming air is then switched into the cleaned channel and the cycle continues automatically.

A second improvement is a new pump which increases the pressure of the liquid oxygen so that it exhausts from the system as a gas at high pressure directly into cylinders. The third and probably most important development is a low-pressure cycle. Air at as low as ninety pounds pressure, cooled in the reversing heat exchangers, is expanded through a new reciprocating engine or a turbine of the type first identified with the name of the Russian scientist, Kapitza, to produce refrigeration necessary for liquefaction. Oxygen is then obtained by fractional distillation of the liquid air to any desired purity. Oxygen generators employing the low-pressure cycle and weighing as little as 150 pounds can even be used aboard an airplane to supply breathing oxygen for personnel on high-altitude flights.

The price of oxygen now depends on the volume consumed—a user of tank-car quantities may pay some 30 to 40 cents for 100 cubic feet, with some reduction in special circumstances. It is estimated that a consumer could operate a low-pressure generator at an estimated cost of, roughly, 2c to 4c for 100 cubic feet;

this figure includes labor and amortization. These estimates have not been proved in commercial practice, but a considerable advantage over conventional methods of oxygen generation seems assured.

At the other end of the scale is a tremendous plant designed to supply oxygen for reaction with natural gas at Brownsville, Texas, for production of synthetic gasoline. Its daily output of 40,000,000 cubic feet almost equals that of all 268 United States plants in 1943. The cost here is estimated at 0.48c for 100 cubic feet; this low cost is based in part on the use, at no charge, of by-product power resulting from other phases of the synthetic gasoline process.

Another possible outlet for cheap oxygen is the conversion of coal to manufactured gas. It has been estimated that such gas could be produced at the mine and delivered by pipeline to Eastern industrial centers at a price competitive with natural gas. Underground gasification of the coal, to avoid mining, has been proposed. Tests showing this method to be economical have been reported from the Soviet Union, but it has not been tested in competition with the mechanized methods of mining employed in the United States. Still another important possibility is the use of oxygen or oxygen enriched air instead of air in blast furnaces. In open hearths for steel making, oxygen-enrichment of the air to achieve higher temperatures is already a means of shortening the overall cycle by reducing the time necessary for melting down scrap.

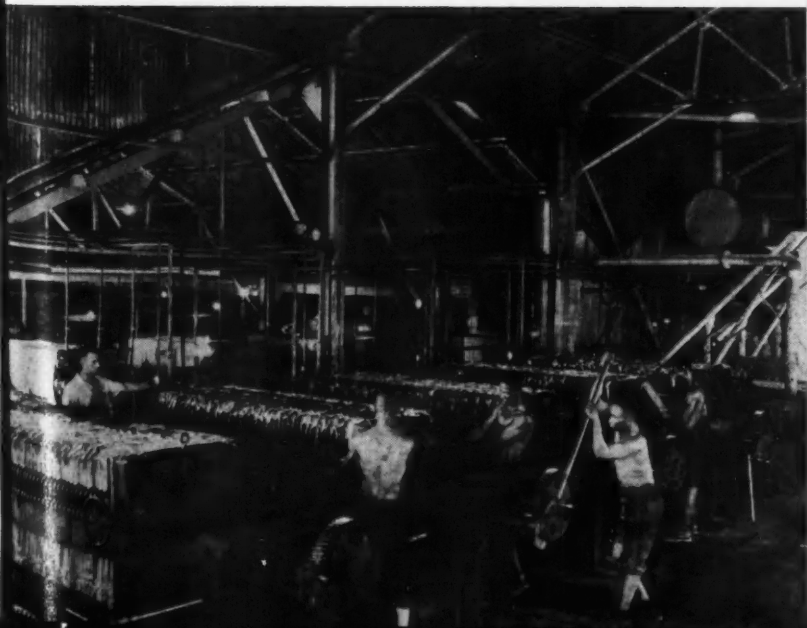
Salt is the most common mineral in existence and one of the most useful.

Filter

► GRAVITY is too slow for most industrial filtering processes. The familiar laboratory set-up of funnel and cone of filter paper, as photographed here by Fremont Davis, Science Service staff photographer, undergoes radical transformation in the plant.

Pulled by suction and pushed by presses, liquids, on the industrial scale, are squeezed violently out of pulpy masses. The truly far-seeing chemist then tries to find a real economic use for the apparently worthless fraction thus separated from the valuable one.

► IN A LOUISIANA cane sugar mill, a battery of filter presses installed by T. Shriver & Co. of Harrison, N. J. are clarifying sugar juices, in the photograph below. Filters of many sizes, for many kinds of material, are offered chemical manufacturers.



Nutrient Solution Disposal

► **PENICILLIN**, conquerer of many diseases, indirectly imposes a public-health problem on the communities where it is produced, which bacteriologists at Rutgers University have been working to solve.

The problem comes from the large quantities of left-over nutrient solution on which the penicillin-producing mold has been raised. It contains a mixture of sugars, plus amyl acetate and other solvent chemicals. Poured raw into the rivers, it would constitute an exceedingly nasty kind of stream pollution, which would provoke no end of protests, and probably restrictive legislation as well.

The soil, from which penicillin originally came, has provided the an-

swer. Dr. Willem Rudolfs and his co-workers at Rutgers made a mixed culture of microbes from a teaspoonful of soil, subcultures from which are able to use up the last bits of nutrient material in the waste fluid and return clean water to the streams.

Two different processes have proved successful. One can be carried on without air, in big steel tanks like ordinary oil storage tanks. The other requires air, which is bubbled through the solution in long rectangular concrete tanks.

The outflow liquid from either type of tank is seeped through sand beds, where other billions of bacteria continue to work on it, until nothing is left but water, ready to go back into circulation.

Bazooka Blasting

► **BAZOOKA-STYLE** blasting charges, with hollow noses, promise higher efficiency, lower costs and greater safety in hard-rock mining. This is indicated by results of experimental work conducted at the property of the National Tunnel and Mines Company, Tooele, Utah.

Bazooka projectiles exploding outside the armor of tanks pierced it with penetrating tongues of "hard" flame leaping out of conical hollows cut into the forward ends of their explosive charges. W. T. Warren, general superintendent of the company, decided that the same principle would be worth a try on rocks. If it would work, it might eliminate a good deal of la-

borious drilling, or the use of excessively large powder charges plastered on the outside with mud.

He was joined by a former Navy officer, E. O. McAlister, who had had wartime experience with underwater demolitions. Mr. McAlister is now in charge of the continuing experiments.

The most efficient charge for mining purposes, it was discovered, is a block of ordinary blasting explosive with a hemispherical cavity in the face to be set against the rock. A little space, or "stand-off distance", between charge and rock improves efficiency.

Preliminary results, on big boulders on the floor and hanging rock "fingers" overhead, are highly encouraging.

Colloid Chemistry Deals With A Special Condition of Matter

Colloids

A Chapter from CHEMISTRY FOR OUR TIMES, in press. Printed with permission of the publisher, McGraw-Hill Book Co., New York.

by ELBERT C. WEAVER and LAURENCE S. FOSTER

► MANY OF US may have wondered why scum forms on hot milk or cocoa while it cools or why a cake of soap is sometimes surrounded by a jelly-like slush. We may have noticed that sometimes jelly does not "jell", that the petal of a white lily has no white substance in it, or that hot water at first is not always best for washing clothers. We may have found ice crystals in ice cream and wondered why frozen desserts and puddings are usually so "smooth" to the taste.

Questions like these and many more were investigated by Thomas Graham (1805-1869), a Scottish scientist. He studied various liquids and the way in which they soaked through parchment paper and animal membranes. He found that solutions of salt and sugar, true solutions, diffuse through these thin, skin-like sheets readily but that liquids such as gelatin and glue in water do not go through so quickly. He called the second group of materials "glue-like" or *colloids*.

Although Graham is called the "father of colloid chemistry" for his work, several other workers of the generation before him prepared and studied colloids also. Since Graham's time, numerous investigators have worked with colloids.

When we investigate colloids we depart for a while from the study of pure substances and investigate natural materials, substances just as they are found in nature to a great extent. This is practical chemistry indeed applied chemistry. But it is not a new chemistry. The story of colloid chemistry is told by applying known principles to a special condition of matter.

What Is Colloidal Dispersion?

Following Prof. Graham's investigations, it was found that "colloids" differ from true solutions in respect to the size of the dispersed particles. We can see large chips of material with the unaided eye. We can also see smaller bits of substances when we use a microscope. Atoms and molecules are very much smaller still, most of them even too small to be seen under an electron microscope. The particles in a colloidal dispersion are intermediate in size; that is, they are too small to be seen by the ordinary microscope but too large to be true atoms or simple molecules. Some of the larger molecules, doubtless, are of colloidal size; the size range is thus general rather than precise.

Colloids are like true solutions in many respects. It is possible, therefore, to think of each of the three states of matter mixed into each of the three

states acting as suspending media. Here are some examples:

Substance suspended	Suspended	Example
Gaseous bubbles	In a gas	Impossible
	In a liquid	A foam — whipped cream
	In a solid	Air in certain porous minerals — meerschaut, pumice—or in floating soap
Liquid droplets	In a gas	A mist or a fog—clouds
	In a liquid	An emulsion — salad dressing
	In a solid	Water in butterfat
Solid particles	In a gas	A smoke
	In a liquid	Colloidal metals in water—house paint
	In a solid	Wings of butterflies—some alloys

However, colloids differ from true solutions in many respects. They do not pass readily through parchment membranes, as Graham found, and they show the path of a beam of light. Just as an automobile headlight sends many streamers of light beams out into the fog, so a light beam shows its path in a colloidal suspension. This effect, called the Faraday-Tyndall effect, sometimes serves to distinguish colloids from true solutions.

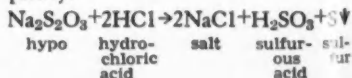
How Colloids Are Made

Some colloids occur naturally. Nature makes starch particles colloidal in size. In fact, it is well known that starch does not make a true solution with warm water. Glue, gums, flesh, and many plant parts are already in colloidal-size particles. Soap put into warm water makes, not a true solution, but a colloidal suspension of soap in water. Milk is a colloid of casein and butterfat suspended in water. Rubber latex resembles milk in appearance and contains tiny particles of rubber hydrocarbon.

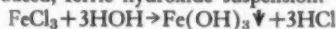
Since colloidal particles are a matter of size, there are only two general ways of making them: (1) making extremely small particles larger; (2) making large particles smaller.

1. Let us start with a solution in the molecular or in the ionic condition. Then let us cause a precipitation to take place in this solution in such a fashion that the particles formed are of colloidal size. Here we can be guided by a principle well known to the druggist. Concentrated or extremely dilute solutions and rapid precipitation cause small-sized crystals. Moderately concentrated solutions and slow separation of the material produce large-sized crystals. A delayed precipitation is startling to watch and illustrates the point under discussion.

If we put hydrochloric acid into a solution of photographer's "hypo," colloidal sulfur forms in the solution after a short while. It is white and opalescent but does not settle out completely.



Let us shake a small amount of solid ferric chloride with cold water. A yellow-brown solution forms that contains Fe^{+++} ions and Cl^- ions. Using the same amount of the chloride, let us add it to a similar amount of water that is boiling vigorously. This time a garnet-red colloid is produced, ferric hydroxide suspension.



Colloidal arsenic sulfide is formed when hydrogen sulfide acts on arsenious acid (H_3AsO_3), and sometimes silver ions and chloride together form silver chloride, which becomes suspended in the solution in colloidal-sized particles. Gold chloride solution treated with a reducing agent, fresh tannic acid solution for example, forms metallic gold colloids, red when heated, violet or blue when cooled and diluted. The color depends on the size of the particle, not its composition.

2. Let some potato starch and water be stirred together. Then let the solution be poured into a folded filter paper and the filtrate tested for starch. A drop of iodine solution produces a blue color if starch is present. No color is produced at first. Now let the starch be ground vigorously in a chemist's mortar with a pestle and the experiment repeated. This time some of the starch cells have been broken open and the starch has been made small enough to pass through a piece of filter paper. This is finely divided, or colloidal, starch.

Mechanical grinding by means of mills produces powders that are colloidal in size. These mills are used to prepare paints, medicines, insecticides, and mayonnaise dressing. In one type

of mill, the grinding is done between two parallel, horizontal, hard steel plates that are so close together that a page of this book could not be placed between them without touching.

Properties of Colloids

Many colloids have attractive colors. Colloidal gold suspended in glass is purple or red. Oil films of colloidal thickness give opalescent, peacock colors when spread out on water. In fact, the color of some flower blossoms and birds' feathers is thought to be caused by air bubbles of colloidal size, or thin plates, for we can discover no colored material (pigment) in them. Nor is any blue substance found in blue eyes. The colloidal substances in the eye break up light and reflect only blue.

Colloidal suspensions in liquids show the path of a beam of light. They pass through an ordinary filter paper. Just as a dog runs through a forest, so a colloidal particle finds its way through the mat of fibers that compose paper.

Let us find out a few things about the effect of surface. To use a homely example, any housekeeper knows that dust gathers on furniture surfaces. The greater the amount of surface, the greater the amount of dust.

Now suppose that we have a cube of cheese one centimeter on an edge. It has six square centimeters of surface. If we slice it parallel to any face, the surface is increased by the area of both sides of the cut, or two square centimeters more. Many thin slices or, better still, grinding will give much more surface, as the table below shows.

Length of edge, cm.	Number of cubes	Total surface	Comparable area
1	1	6 sq. cm.	A large postage stamp
0.001	1,000,000,000 (= 1×10^9)	6000 sq. cm.	A small rug
0.000,001	1×10^{18}	600 sq. meters	A home-size building lot
0.000,000,01	1×10^{24}	15. acres	A city block

That is, the surface from a lump of sugar, fine pulverized, is more than all the floor space in a large high school. Any surface effect, then, is brought out in colloids to a remarkable extent.

Colloids *adsorb* many substances readily; that is, substances cling to the surface of a colloid. Notable in this respect is activated charcoal, made by charring selected vegetable material. Brown sugar solution is boiled with activated charcoal, and the coloring materials are adsorbed. The sugar becomes colorless. Bone black also shows the same property, but not so much as activated charcoal. Activated charcoal is used as an adsorbing agent in general military defensive gas masks and for purifying water. Ordinary charcoal spread over vile-smelling, putrid organic matter will make it tolerable for a while. From a bottle full of freshly heated and air-cooled

activated charcoal, several bottles full of air may be collected by pouring in water. This is because the charcoal has adsorbed so much air.

Experiments also show that particles in a colloid are usually charged electrically. In ferric hydroxide, for example, all the particles are charged with the same kind of electricity, positive. Hence, the colloidal particles repel each other and tend to stay suspended and apart. Colloidal arsenic sulfide has a negative charge. The electric charge on colloidal mist is thought to be connected with thunderstorms.

The fact that colloids are usually electrically charged accounts for some of their most interesting properties. Indeed, colloidal particles behave quite like ions at times. Rubber colloids may be electrically plated onto metal articles, producing adhering coatings.

Mineral Oil Is Food Adulterant

► THE OIL and fat shortage is having health repercussions. Numerous cases of stomach and intestinal upsets have been occurring. Health authorities ascribe them to mineral oil used as a substitute for edible oils in salad dressings.

The American Medical Association

repeats its warning that taking mineral oil can seriously interfere with the absorption of carotene from which the body makes vitamin A, and vitamin D, calcium, phosphorus and vitamin K, and that it should be used under the supervision of a physician.

The Didymium Fraction Yields Some Surprises

Twin Elements

A Classic of Chemistry

► A NEW RARE EARTH, which was named for the man who found the first one and opened a new chapter in analytical chemistry, is described here by its discoverer. Following the reprint of the communication which announced the separation of the new element from its companions in the mineral samarskite, comes the graceful little note in which two leading chemists of the eighties paid their compliments to each other over the naming of gadolinium.

Then the great sensation of its day, the splitting of didymium, accomplished by fractional crystallization, car-

ries the story of the rare earths and how they developed analytical procedures down to modern times and methods. First, differences in solubility were exploited, to use techniques of solution and precipitation. Then fractional crystallization was developed to separate elements whose compounds are similar in properties. Use of the spectroscope to determine purity comes to perfection in this month's *Classic of Chemistry*. Only with the researches of the Plutonium Project of World War II have these methods been topped by more exact techniques.

Gadolinium

ON THE EARTHS OF SAMARSKITE. *Note from M. C. Marignac. COMPTES RENDUS 90: 399, April 19, 1880. Translated for CHEMISTRY by Helen M. Davis.*

► I HAVE CONDUCTED for two years a series of researches upon the earths of American samarskite. I have forced myself to follow a completely systematic course, which may be very long, but with the help of it I hope, if I can continue it to its completion to determine the presence of all the bases of this group which enter, to any notable proportion, into the composition of this mineral.

After having extracted the crude

earths by the usual procedures, I have separated them first into several fractions by successive decomposition of their nitrates by heat. Each of these will soon be analyzed in its turn by other methods.

For the present I have concerned myself only with the portion of these earths whose nitrates decompose last. This is the part richest in yttrium, it is the part also in which is concentrated almost all the didymium. On the other hand, one is sure of not finding here any of the earths whose nitrates are decomposed easily (erbium, ytterbium, scandium, etc.).

In order to separate the different

earths which are found here, I have had recourse to their difference in solubility in a saturated solution of potassium sulfate. But even though they show very great differences in response to this treatment, they affect each other reciprocally to such an extent that it is only after such treatments repeated hundreds of times that one begins to make an approximate separation.

Since the beginning of this work, it has been established that as a rule when going from the most soluble to the least soluble they show the following modifications.

First, from a pale yellow color and an equivalent weight near that of yttrium, they become colored more and more orange-yellow while at the same time the weight increases. The coloration reaches its maximum for those products whose weight is between 113 and 118, then it diminishes as the weight continues to increase up to about 120. After that time the solubility in potassium sulfate decreases very rapidly, while the yellow coloration disappears and the equivalent weight decreases slowly, approaching that of the oxide of didymium, yet remaining a little way from it.

In accordance with these preliminary observations, I have divided my earths into four portions:

1st. Earths soluble in less than 100 parts of potassium sulfate, whose weight is less than 119;

2nd. Earths soluble in 100-200 parts potassium sulfate, whose weight varies from 119 to 120;

3rd. Earths very slightly soluble in

potassium sulfate, weight ranging between 119 and 115;

4th. Earth practically insoluble. This is oxide of didymium, but holding very strongly a certain quantity of the preceding earths. I have pushed the extraction of these to the point where the solution is saturated with potassium sulfate, where didymium-potassium sulfate begins to be formed, retaining no more than 1/40,000 of the earth. It is unfortunate that the oxide of didymium is far from being completely freed from these earths.

Let us take again, successively, the first three groups.

1. *Earths soluble in less than 100 parts of potassium sulfate.* Upon continuing to give this the same treatment, it can be shown that the greater part dissolves in less than 30 parts of the solution. The rest owes its lessened solubility not only to the presence of a certain quantity of earths of the following groups, but also to the fact that they are redissolved by the repeated operations.

As for the more soluble earths, treatment with potassium sulfate is not sufficient to separate them, so this is accomplished at this point by using the difference in solubility of their formates. I have satisfied myself by this treatment that this group contains but two earths now known, yttria and terbine.

11. *Earths soluble in 100 to 200 parts of potassium sulfate.* If we continue to use the same method of concentration, separating the more soluble parts, rich in terbine from the less soluble, which contain the earths belonging to the following group, we see the equivalent weight rise again,

but very slowly. I have not been able to pass the maximum of 120.5.

The earth thus obtained is soluble in 100 to 150 parts of potassium sulfate solution. Its color, a rather pale orange, is perhaps due to a small quantity of terbium which I have not been able to eliminate completely. The salts and the solutions of this base are colorless; they do not show an absorption spectrum; we can distinguish only some traces of the lines of decipium and didymium. For the rest, all that I have seen of these salts do not differ in any way from those of the other earths of the yttrium group.

The fact that a maximum appears in the equivalent weight of this earth between the two neighboring groups proves incontestably its existence as a distinct entity. It cannot be confused with any of those which have been distinguished up to now. Its weak coloration, supposing this really to belong to it, and the absence of an absorption spectrum do not permit us to put it with yttria and ytterbium. Its high equivalent weight removes it completely from the first, it differs from the second by a much greater basicity. Its nitrate is more resistant to decomposition by heat than that of terbium, which is, itself, decomposed with much greater difficulty than that of ytterbium.

I shall designate provisionally this earth as Y_{α} ; it will be time to give it a name when we can obtain it in the pure state, and in sufficient quantity to make a study of its salts. Perhaps it will be found to be identical with that of which M Delafontaine, in a recent

note, says: "I am examining also another base from samarskite, which seems to resemble ytterbium very closely."

III. *Earths very slightly soluble in potassium sulfate.* By following the application to these earths of the same method of separation, we establish there the presence of (1) a little terbium and a notable quantity of the preceding Y_{α} , which is eliminated, but never completely, by rejecting all the parts more soluble in potassium sulfate; (2) oxide of didymium which may be separated, but incompletely also, by rejecting the parts less soluble in potassium sulfate, or by fractionating the products by partial decomposition of their nitrates by heat or by successive precipitation with ammonia, basing this on the greater basicity of this oxide; and (3) finally, an earth which demands more than 2000 parts of potassium sulfate to dissolve it, which is almost colorless, showing no more than a slight salmon tint, and which I have provisionally designated as Y_{β} .

Its equivalent weight has dropped to 115.6; the very small quantity of didymium which it retains (about 3 to 5 parts per 100) cannot influence this weight very much. I consider this, rather, a maximum, by reason of the presence of the preceding earth.

But the most essential characteristic of this earth consists of its absorption spectrum. Its solutions show, in fact, in their spectrum, particularly in the blue and the violet, lines of extreme intensity. According to my observations, complemented by those which

M. Soret has been kind enough to make, these lines correspond exactly with those which M. Delafontaine has indicated as characteristic of his decipium, and still better with the very detailed and precise description which M. Lecoq de Boisbaudran has given, which he attributes to the oxide of a new metal which he has designated by the name of *samarium*.

It is impossible not to admit that these three earths are identical, at least as to the nature of the principle which comprises the greater part of them and determines their absorption spectrum. It would be difficult, besides, to understand how it could be otherwise, since all three of them have been extracted from the same mineral by the same process.

So I would have no hesitation to call this earth by the name decipium, for it seems natural to me to preserve the name which was given it by the first author of its discovery, if only it did not present, compared to decipium as described by M. Delafontaine in his most recent Notice, two important differences which it is impossible for me to account for.

These differences consist in the pale yellow coloration of the solutions and of the salts of my earth Y_{β} , while decipium formed colorless salts, and especially in the enormous difference in equivalent weight, which was at least equal to 130 for decipium, while I have found only 115.6 for my earth and I consider even that number a maximum.

These divergences can only be explained by further researches which I am not at the moment able to pursue,

not having a sufficient quantity of material for them.

Summing up, the principal part of the earths from samarskite is composed of yttria, which is the main element, terbine, a new earth Y_{α} , and a small quantity of oxide of didymium and of an earth which, if it is not pure decipium, is at least in large part composed of it.

Gadolinium Named

M. MARIGNAC'S Y_{α} IS DEFINITELY NAMED GADOLINIUM. *Note from M. Lecoq de Boisbaudran. COMPTES RENDUS 102: 902, 1886. Translated for CHEMISTRY by Helen M. Davis.*

► IN THE COURSE of correspondence in which I have recently had the honor of taking part with M. de Marignac, I have taken the liberty of calling the attention of that illustrious chemist to the advantage it would be, for those who work with the rare earths, to see Y_{α} at last receive a definitive name from the author of its discovery. This interesting substance Y_{α} has been studied so well for a long time and its spectrum shows such clear characteristics that there can no longer be any doubt as to its individuality.

M. de Marignac has had the kindness to entrust to me the announcement to the Academy that he has chosen the name *gadolinium* (symbol Gd) for the metal of Y_{α} .

The drawing of the spectrum of Gd_2Cl_6 , which I have the honor to place before the Academy, will without doubt interest the scientists who concerned with the chemistry of minerals.

Praseodymium and Neodymium

THE SPLITTING OF DIDYMIUM INTO ITS ELEMENTS, by Dr. Carl Auer v. Welsbach (from the university laboratory of Prof. A. Lieben. Presented at the session of 18 June 1885). MONATSHEFTE FÜR CHEMIE, Vienna, VI: 477, 1885. Translated for CHEMISTRY by Helen M. Davis.

► THE END RESULTS of my researches on the group of metals of the rare earths, so far as they touch upon territory unknown or little known to science, I am treating in a series of separate publications, in order to bring together more easily the more interesting parts of this work.

A new separation technique, fractional crystallization of the ammonium double nitrates of lanthanum and didymium in strong saltpeter solution, in which these substances behave very differently, makes it possible not only to separate lanthanum completely from didymium in a few operations and obtain it practically pure for the first time, by which any desired quantity may be worked over with almost the same amount of trouble, but also to separate didymium itself into its specific components. After repetition many hundred times of the separation procedure the separated elements remained in abundant quantity and in the pure state.

The absorption spectra of the compounds of these elements are part of that hitherto considered as the characteristic absorption spectrum of didymium. When these elements are combined in the proper percentage, both the color of the solution and the orig-

inal spectrum of didymium appear again unaltered.

The spectrum of didymium is indeed in the true sense the sum of the absorption spectra of the new elements.

The emission spectrum characteristic of didymium belongs to a single substance, all of whose intense absorption bands coincide with the lines of the incandescent earth.

The spark spectra of the new elements are brilliant and these similarly are to some extent part of the spark spectrum of didymium.

The compounds of the two new elements, now prepared pure, are of different colors. Those of the first, the one standing next to lanthanum, are a pure and intense leek-green, those of the latter, the one standing farther from lanthanum, are practically pure rose or amethyst color.

The latter element makes up the chief part of the "decomposition elements" of didymium.

The methods employed in this work for production, determination of spectrum, etc., will be found in brief in my paper submitted to the Academy of Sciences, "Contributions to Spectrum Analysis."

Since now the true splitting of didymium into several elements has been realized, I propose not to strike out the name didymium completely and suggest, for the first element, in accordance with the green color of its salts and its derivation, the name: Praseodymium with the symbol Pr, and for the second, as the "new didy-

mium," the name: Neodymium with the symbol Nd.

From the atomic weight determination, which was carried out in every detail according to Bunsen, the provisional weight for praseodymium works out as 143.6, for neodymium as 140.8, from which the corresponding oxide gives the general formula M_2O_3 .

The properties exhibited by the two elements are sufficient to clarify many very widely contradictory results of chemical investigation hitherto shown by didymium.

I have, in the course of my exposition, spoken of more than these two elements. This is due in part to the remarkable relationship of the absorption spectrum of preparations with the neodymium lines. This spectrum appears only after pursuing it with the help of larger spectrum apparatus with stronger dispersion; I shall come

back to this in the case of determined results in my publication on the wavelengths of spark spectra of the new elements. To announce anything about this at the present time would be premature; this much only may be said, that, should further research in this territory bring out the existence of newer substances, these could only be present in didymium in minimum quantities.

I have not emphasized further the characteristic behavior of lanthanum in the last position. It can scarcely be doubted that this substance, sooner or later, as now didymium, its "twin brother," will be cut from the list of elements.

In this place I should like to give Prof. A. Lieben and his assistant, Dr. S. Zeisel, my especial thanks for the friendly solicitude with which they assisted me in my work.

Who's Who in This Month's Classic

► CARL AUER VON WELSBACH (1858-1929) was primarily a chemist and his invention of the incandescent gas mantle was an outgrowth of his study of the rare earths. In splitting didymium into two elements, which others before him had suspected possible but had failed to accomplish, he displayed the masterly techniques he had learned in Bunsen's laboratory.

Brief accounts of MARIGNAC and LECOQ DE BOISBAUDRAN appeared in the November issue of CHEMISTRY in connection with their earlier discoveries. They are reprinted here because

these men were active in the discoveries described in this month's classic as well.

JEAN CHARLES GALISSARD DE MARIGNAC (1817-1894) was a Swiss chemist, educated in Paris, later Professor of Chemistry at the Academy of Geneva. He played a prominent part in the discovery of several of the rare earths.

PAUL EMILE FRANCOIS LECOQ DE BOISBAUDRAN (1838-1912) was a French chemist who worked with the rare earths and spectroscopy. He discovered Gallium in 1875, Samarium in 1879 and Dysprosium in 1886.

A Bit of Chemical "Magic"

Tricks with a Sugar Lump

by JOSEPH H. KRAUS, *Science Clubs of America Editor*

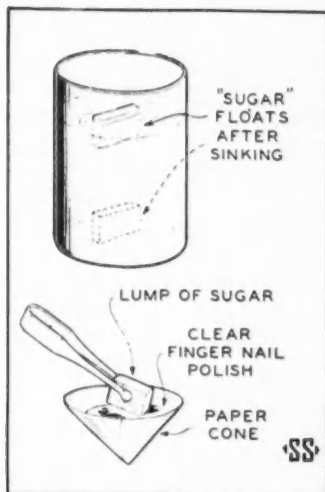
► IMAGINE DROPPING a lump of sugar into your cup of tea or coffee only to have it rise to the surface, a few minutes later. A simple treatment of a sugar lump makes it possible to foretell almost the precise second at which the sugar lump will reappear at the surface.

Into an ordinary paper drinking cup or paper funnel pour some colorless finger-nail polish. This can be purchased at any drug store or five-and-ten-cent store. Holding the lump of sugar in a pair of tongs, immerse it in the clear polish. Let it remain there for about half a minute, then shift the position of the tongs on the lump so that it is completely exposed to the lacquer. Remove the sugar and set aside for at least a day to dry completely.

Return the clear finger-nail polish in the paper cone to the bottle by setting the apex of the cone over the mouth of the bottle and then poking a hole through the bottom with a needle or pin. In this way you will be able to collect most of the polish and avoid having to wash the film from a funnel or dish.

Drop one of the lumps of sugar in a glass of water, hot coffee or tea. Watch it sink to the bottom of the liquid, then bob to the surface again.

If you treat several lumps of sugar in exactly the same way, count the number of seconds required for the lump to reappear. Then the next time



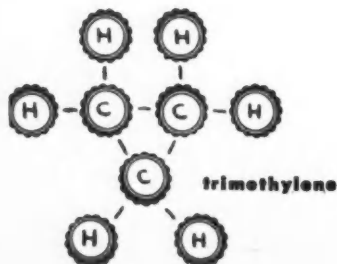
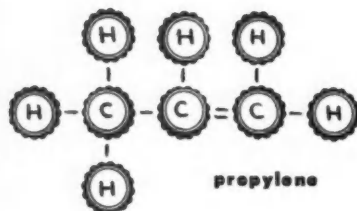
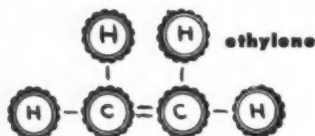
you demonstrate the experiment with a lump made in the same manner and in liquid of the same temperature, almost exactly the same interval will pass before the lump reappears to float on the surface.

Hollow Lump Floats

The coating of lacquer on the outside of the lump completely imbeds some of the grains and otherwise covers the surface of the sugar. After it is dry it looks like any other non-treated lump. When dropped into a liquid, the sugar dissolves out and the lacquer shell which rises to the surface bears a very close resemblance to the original lump.

Double and Triple Bonds

► THE REMARKABLE ABILITY of carbon to form complicated compounds is chiefly responsible for making our earth what it is today. Not only does carbon combine with most of the other light elements, it has a unique ability to combine with itself. In this series



of diagrams, which aims to outline a review course in the main types of organic compounds, the formulas covered so far have been for compounds of the paraffin series. In those compounds the valence bonds of carbon which hold the chain-like molecules together string themselves out as

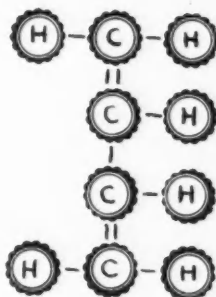
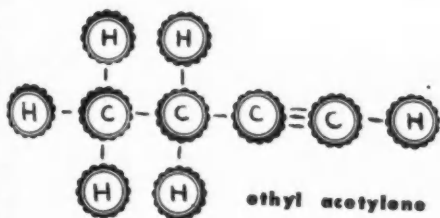
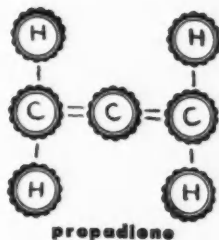
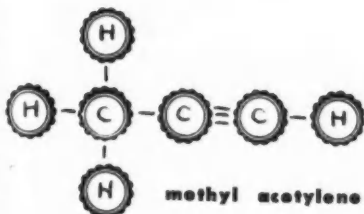
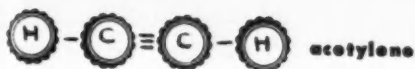


and the other two valences of the mid-chain atoms hold atoms of hydrogen or some other element.

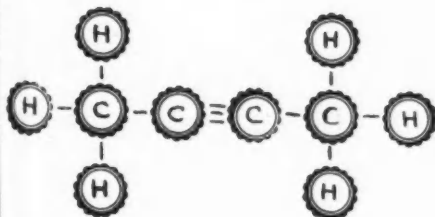
Carbon atoms, however, are able also to hold onto each other by two and by three of their valence bonds. When two bonds join a pair of carbon atoms, the resulting series of compounds has the general formula C_nH_{2n} . The series takes its name from ethylene, the first member: C_2H_4 . The chain is extended in the same way that the paraffin series is, by adding CH_3 in place of one of the hydrogen atoms. Thus the enormous series of compounds possible from the paraffin series can, at least theoretically, be duplicated in the ethylene series.

Another name used for compounds containing the double bond is diene. Butadiene is the member of the series which corresponds to butane in the paraffin series. The name butadiene has become familiar because compounds of this series enter into the constitution of synthetic rubber.

Again, a third series of compounds



divinyl or butadiene



dimethyl acetylene



diacetylene

is formed when the pair of carbon atoms which starts it is joined by triple linkage: $C\equiv C$. The simplest member is acetylene, C_2H_2 . In this case there is but one bond available from each of the two carbon atoms to hold a hydrogen atom or a group substituting for it. The general formula is C_nH_{2n-2} .

Hydrocarbon compounds whose atoms are joined by more than one bond are called unsaturated. They break the extra bonds quite easily when given the opportunity to combine with more hydrogen or other reacting groups, and go over to the corresponding compound in the paraffin series.

The three hydrocarbon series, the paraffin (C_nH_{2n+2}), the ethylene (C_nH_{2n}), and acetylene (C_nH_{2n-2}), with all their manifold substitution products, make up the bulk of the straight-chain molecules with which

the organic chemist concerns himself. Straight-chain compounds are grouped under the name of the aliphatic series.

The other great group consists of substances whose carbon atoms, instead of linking one onto the other to form a chain of indefinite length, join in definite numbers to form rings. The most famous of these is the benzene ring: C_6H_6 . Compounds containing the benzene ring are spoken of as the aromatic series, for it is among such substances that we find the structures of perfumes and flavorings. Ring structures may, however, be formed by other carbon groupings, and some take in an atom of oxygen, nitrogen or sulfur, or occasionally other elements, to form other series. Rings containing elements other than carbon are referred to as heterocyclic compounds.

Body Economics Demands Meat, Fats

► CONSUMER DEMAND for meat or other protein and fats for food is tied up with the economics of the human body as well as with the economics of the market place, it appears from a report by Dr. E. B. Forbes, emeritus professor of animal nutrition, Pennsylvania State College, at the 100th birthday celebration of the University of Buffalo School of Medicine.

Fat and protein, he reported, favor the transformation of food into body substance with less energy waste than would be supposed from the effects of individual foodstuffs. It is not surprising that fat and protein are thus economically transformed into body substance, since human and

other animal bodies are made up mainly of fat and protein.

A lot of people have very wrong ideas of the effects of foods in nourishing the body, Dr. Forbes declared. The reason for these wrong ideas is that they are based on study of the effects of one class of foods alone.

The once-popular notion that meat or other proteins should not be eaten in hot weather because of their heating effects is an example of some of these wrong ideas.

Meat or other protein food which has the highest heating effect when fed by itself has the exactly opposite effect when fed in a mixed diet.

Measuring Invisible Particles Improved by New Techniques

Sizes and Shapes of Molecules

► THE SIZE and shape of the polymer molecules making up materials supplied to the Army was the clue to whether the equipment would be satisfactory in use, according to Dr. Herman F. Mark of the Polytechnic Institute of Brooklyn, speaking at a recent symposium on chemical engineering problems held at the Institute by a division of the American Chemical Society.

Advances in the technology of plastics have been so rapid in the United States, Dr. Mark said, that they have outstripped progress in the fundamental knowledge of polymer chemistry as far as industry is concerned. The war made it necessary to apply the fundamental knowledge of plastics chemistry to materials, to find out how they would react when used by the armed forces.

The Army Quartermaster Corps, through the National Research Council Committee on Quartermaster Problems, sought the aid of science to determine the quality of materials purchased for a variety of purposes.

Some covering materials for food and guns, as well as clothing for soldiers, failed to stand up under military use, although the materials appeared suitable, and the Army had to learn what was wrong.

The answer was found to depend partly on the size and shape of the polymer molecules making up the materials, according to Dr. Mark. In

producing tough, durable coverings to protect metal equipment from rust, to replace coated fabrics used for mountain tents, raincoats and ponchos so as to make them lighter in weight, and to provide suitable coverings for food, it was found essential for the manufacturer to know whether the solution he employed to make the final film was composed of long, straight molecules or curled-up molecules.

The measurement of light scattering was described by Dr. Mark as a new method for determining molecular size and shape which will give the plastics industry a better way of studying its products. He reported on the successful wartime use of the ultracentrifuge in investigating the molecular make-up of materials.

Pigment Particles

How the size of paint pigment particles as small as two one-millionths of an inch in diameter—too minute to be seen with an optical microscope—can now be measured rapidly and with a high degree of accuracy was told at the symposium by Emerson D. Bailey, of the Experimental Station of E. I. du Pont de Nemours & Company at Wilmington, Del. The technique, worked out in the laboratories of the Experiment Station's chemical department, consists in passing light of different colors through a suspension of the powder in a liquid and then measuring the amount of light of each color which emerges. Suspensions contain-

ing particles of different sizes transmit different colors to different degrees.

From the data thus obtained, Mr. Bailey said, the average size of the suspended particles is calculated and a curve is obtained showing the relative amounts of each particle size present. The whole operation can be carried

out in about two hours with relatively simple equipment. Measurement of particle size is important in a wide variety of technical investigations, such as research on white pigments for paints and enamels where quality of the finished product is dependent to a considerable degree upon the size and uniformity of the pigment particles.

Manganese by Electrolytic Method

► ANOTHER LESSON of the war is that America can produce its own manganese, a number one essential in making steel. However, it can not do it yet at a cost low enough to compete with ore from foreign countries. A low-cost method would mean independence from importation.

An electrolytic method developed by the U. S. Bureau of Mines may be the answer. During the three years that its Boulder City plant has been in operation, it has produced over a million pounds of electrolytic manganese. This is only a small part of the requirements, however.

Despite the fact that the United States has large deposits of manganese ore, nearly all the manganese requirements of the steel industry before the war were imported, the Bureau states, because most of the domestic ores are low-grade and have proved difficult, and in some instances impossible to concentrate to ferro-grade by ore-dressing methods.

The Bureau feels, however, that it has successfully demonstrated the technical and commercial feasibility of electrolysis in beneficiating low-grade manganese ores, particularly where the raw materials and electricity are

available. It has issued a publication reporting the process.

For every ton of steel produced in the United States, an average of over 13 pounds of manganese is used. Most of it is in the form of ferromanganese. During 1940, nearly 45,000 tons of manganese were produced in the United States, but over 1,400,000 tons were imported. In 1944, domestic production was five times as great as in 1940, and importation had decreased slightly.

In the production of ferromanganese, and other usable manganese compounds, America does better. The home production is about four times the imports. Imports of both manganese ore and ferromanganese come in normal times from Brazil, Chile, Cuba and Mexico, in the Western Hemisphere, and from Africa, India and Russia. The Soviet Union occupies a favorable position in steel production because it has, in the Ukraine, iron ore, manganese, limestone and coal all relatively close to each other.

Manganese is added to the open-hearth melt to increase tensile strength, and to remove surplus oxygen and sulfur. Manganese in pig iron is desirable in removing sulfur.

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Dissolved Silica Removed by Iron

► A NEW PROCESS for taking dissolved silica out of water before it is used in steam boilers utilizes rusted cast iron chips to absorb the undesirable substance which, if not removed, would form scales within the boiler tubes.

The process was explained at the meeting of the American Society of Mechanical Engineers by Walter Leaf, of the Denver and Rio Grande Western Railroad company, who developed it.

In an investigation carried out over several years to find a solution to the boiler scaling problem due to silica in the water, it was discovered that hydrous ferric oxide formed from rusting steel shavings from a lathe, in the presence of the water to be treated, was very effective in removing the silica.

However, this method, while satisfactory at Denver, was not satisfactory at Alamosa, Colo., where the railroad got its water from a 600-foot artesian well, because of the high silica content of the water obtained. It was decided that the high silica content must form a protective coating over the steel shavings, preventing further rusting. Finally the use of cast iron freight car

wheel borings was investigated, and proved satisfactory.

Cast iron contains particles of free carbon, which are electronegative to iron, so that electrolytic corrosion of the chips is very active, he explained. Cast iron has a good record of rust-resistance, but there is a protective coating of high silica iron, formed from the sand mold, over the surface of the pipe. Once this coating is penetrated, Mr. Leaf stated, corrosion of the cast iron may be rapid.

In the treatment tank into which the water is sprayed, cast iron chips from the railroad wheel plant were put on top of some of the steel turnings previously utilized. To prevent the chips from cementing themselves together, a motor-operated revolving rake was built whose teeth extended about three inches into the chips. The motor is provided with a timing device, and operates for a minute every hour, sufficient to keep the chips from cementing.

Advantages of the method, Mr. Leaf stated, in addition to dissolving the silica, are its low cost and the fact that no additional soluble salts are introduced into the boiler water.

On the Back Cover

► AN EXERCISE in pure form, these beautiful shapes result from plotting mathematical equations in three dimensions. These models were constructed by Rutherford Boyd at Columbia University. The photograph is by courtesy of the journal *Scripta Mathematica*.

New Phosphor Shines by Infra-Red

► A TINY BIT of lead added to zinc sulfide, a phosphor material that glows after exposure to light, makes invisible infra-red rays visible, a scientist of the General Electric laboratory has found. The discovery may eliminate electronic methods now used.

This easy way to change invisible rays into visible ones may be used to simplify the famous Army sniperscope and snooperscope used by soldiers during the war to see in the dark, themselves unseen. It may also simplify the receivers used on Navy vessels to read infra-red signals from other ships.

Dr. Gorton R. Fonda, responsible for the discovery, explained that waves of infra-red radiation are too long to affect the eye, while those of ultraviolet are too short. However, the ultraviolet is easily made visible by the phenomenon of fluorescence used in the fluorescent lamp. In the lamp tube

in which they are generated they fall upon the phosphor with which the tube is lined, their wave lengths are increased and they emerge as visible light.

Fluorescence by itself can not make infra-red radiation waves shorter; it can only make them longer. However, there is an indirect way in which they can make visible light come from a phosphor.

Some phosphors, he explained, show phosphorescence; they continue to glow for a time after the original radiation has been removed. If, while this glow remains, the phosphor is exposed to infra-red, the brightness may be slightly increased. After that it quickly fades out. Dr. Fonda found that the effect, previously known to other scientists, occurs with zinc sulfide, a common phosphor, provided it contains a fraction of a per cent of lead.

Answers to Chem Quiz on Page 15

1. Jack Spratt got all the protein at his house.
2. Little Jack Horner stuck in his thumb and pulled out a (sugar) plum.
3. Jack and Jill got the water, and he mended his head with vinegar and brown paper.
4. Jack jump over the candle stick.
5. Little Miss Muffet was eating her curds and whey.
6. Humpty Dumpty is universally reported to have been a good egg.
7. The captain was a duck, (remember?) of the ship whose sails were all of velvet and her masts of beaten gold.
8. Mistress Mary, quite contrary, grew silver bells with her cockle shells.
9. There was a little man, and he had a little gun, and his bullets were made of lead, lead, lead.
10. Queen, Queen Caroline Washed her hair in turpentine.

Spectacular Chemical Light For Mystery Stage Effects

Cold Light Makes Good Exhibit

► **COLD LIGHT**—light produced without generation of heat—an eerie colorful spectacle encompassing the phenomena of fluorescence, phosphorescence and chemiluminescence, may well be the nucleus of a spectacular chemical magic stage demonstration put on by the chemistry club.

Fluorescence is the property exhibited by certain substances of giving off radiation which is being absorbed from some other source. Phosphorescence is the property of continuing to give off light after the source of radiation has been removed. Chemiluminescence is the emission of light by a chemical solution, without special irradiation.

Fluorescence, in various colors, may be demonstrated effectively in darkness by directing the ultra-violet rays of a mercury or argon lamp on various materials. For example: natural substances such as Sphalerite will glow orange; Dolomite, yellow; and Zincite, green. Solid organic chemicals will also glow: pure Anthracene, blue violet; Salicylic Acid, pale violet; Dihydroxybenzoic Acid, greenish blue. Liquid organic chemicals may also be found to glow. For example: Esculin in a water solution will shine blue, Phenosafranine, also in a water solution, will glow yellow. Eosin, in an alkaline water solvent, appears green. Purpurin dissolved in an alum solution appears yellowish-red.

Club members may conduct many fascinating experiments in determining which natural and organic compounds will show up best in a stage demonstration. Texts on organic chemistry will be very helpful in suggesting materials.

Ingenious club members may paint words with fluorescent paint on cardboard. These will show up under ultra-violet rays. The words "welcome" at the start of a chemical magic show and "end" at the close will be well received.

A bit of surprise may be introduced when teeth are exposed to the ultra-violet rays in the darkness. Natural teeth can be distinguished from "false" teeth. Teeth will glisten because of certain substances containing minute amounts of impurities that fluoresce. Teeth that have been pegged will show up only as black. The FBI uses the principle of fluorescence to examine letters suspected of containing messages written in secret ink.

While looking at the rays the eyesight is slightly blurred. This is because the rays cause the liquid surrounding the eyeball to fluoresce.

Chemiluminescence or "liquid light" may be used in many chemical magic tricks. The organic compound 3-Aminophthalhydrazide, called "luminol," is used in all the experiments that follow.

When a weak solution of this or-

ganic chemical is mixed with a weak solution of an oxidizing agent, a cold eerie light is produced. Mixing solutions of Type I gives a greenish light which lasts several minutes. Those of Type II give a much more brilliant blue light, but it lasts only a few seconds.

The solutions for these two types of chemiluminescence are as follows: Type I uses solution A, made by dissolving 0.10 grams of luminol in 10 c.c. of 5% sodium hydroxide solution, and solution B made by dissolving 0.25 grams of potassium ferricyanide in a little water and adding 10 c.c. of ordinary 3% hydrogen peroxide. Dilute each solution with water to one liter, and keep them separate.

Type II uses solutions X and Y.

Solution X is made by dissolving 0.10 grams of luminol in 10 c.c. of 5% sodium hydroxide solution and diluting to 200 c.c. When ready to use, add 5 c.c. of ordinary 3% hydrogen peroxide. A faint luminescence will appear, but the power of the solution will not be destroyed for several hours. Solution Y is made by diluting to one percent an ordinary sodium hypochlorite, household bleaching solution (the type usually sold in a grocery store which is about a 5% solution).

CAUTION: *Use these solutions with care. Sodium Hydroxide has caustic properties. Keep the solutions away from the eyes, wash hands immediately after using solutions, keep solution, even in a spray, away from clothing.*

Methods of Demonstration

Method 1—When solutions A and B are mixed, a greenish blue light results which will last for several minutes. If stronger light is desired, add a few crystals of the potassium ferricyanide and a little more of the sodium hydroxide solution. The light evolution can be suddenly stopped by adding about 50 c.c. dilute (1 normal) hydrochloric acid to neutralize the sodium hydroxide. The light can be quickly restored by adding 5% sodium hydroxide to neutralize the acid—usually about 60 c.c. will be sufficient.

Method 2—To show that heat is not involved, the production of light on a cake of ice or a bowl of ice water makes a spectacular demonstration. Take two liters of a mixture of ice and water, preferably about two-

thirds water with most of the ice in one large chunk floating on top. Simultaneously, pour solutions A and B on the cake of ice. They will mix and flow down into the ice water giving off a very bright greenish blue light and making the whole mixture luminous.

Method 3—Spray solutions of A and B together using a spray gun. A fine luminous green mist will be produced with varying light intensity depending upon the strength of the solutions used. A bright blue mist, although of shorter duration, will be produced if solutions X and Y are used instead.

Method 4—Soak an ordinary face towel in a liter of solution A. Wring out the excess liquid, and lay the towel on a table. Pour a little of solu-

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tion B directly upon the towel, from sufficient height to give a splashing effect. The towel will glow brightly and when wrung out liquid drops of "fire" will fall. To give a more spectacular effect, it may be waved up and down while the fiery drops continue to fall. The same effect, but in brighter color, may be produced with solutions X and Y.

Method 5—Another way of demonstrating liquid light is to moisten one hand with solution A or X and the other with B or Y. Clap the hands together, pressing each finger against the opposite one. When hands are opened, they will glow green or blue, depending on the solutions used.

"Putting on a Show in the Chem Laboratory" is the title of one of the monographs prepared especially for Science Clubs by Science Clubs of America. This interesting leaflet tells how the Science Club of Fort Plains

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ever, they did not use cesium, sometimes spelled caesium.

The advantage of cesium, a metal of the sodium, potassium, lithium, rubidium group together known as the alkali metals, is that it is an efficient generator of infra-red waves, also a poor visible illuminant. Its low visibility minimizes requirements for a filter to block out stray visible light which would betray the presence of the signal system.

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